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Doug LeBlanc
St. Cloud State University

Ettien Koffi
St. Cloud State University

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A LABORATORY PHONOLOGY ACCOUNT OF THE PAST TENSE SUFFIX <-ED> AND ITS ALLOMORPHS

DOUG LEBLANC AND ETTIEN KOFFI

1.0 Introduction

For much of its history, phonological accounts of pronunciation have relied almost exclusively on the impressionistic judgments of how linguists pronounce the segments, words, phrases, or utterances under investigation. However, since the late 1980s a gradual change is underway which calls for an increased use of instrumental phonetic methods to bolster or validate the claims made by phonologists. Even Pulleyblank (2012), a well-known theoretical phonologist, is on board with this new approach. In his plenary address entitled “*Issues in the Phonology-Phonetics Interface in African Languages*,” he calls for the integration of the two sub-disciplines of linguistics because he contends that instrumental phonetics can help accomplish the following:

1. Check what we hear or see
2. Figure out what’s going on when something is hard to hear or see
3. Determine (potential) patterns that cannot be heard or seen

Thomas (2011, p. 10) provides essentially the same rationale in advocating for an increased use of instrumental phonetics in sociolinguistics research. He claims that a move away from the traditional impressionistic approach is necessary because “acoustic analysis can reveal details of consonantal variation that are difficult or impossible to gauge using impressionistic analysis.”

A new field of inquiry was born in 1987 when Mary Beckman and John Kingston organized a linguistic conference at The Ohio State University. One of the main goals of the conference was “to bridge the distinct subfields and subcultures of phonology and phonetics.” The blend between the two sub-disciplines is now known as *Laboratory Phonology*. The phrase “Laboratory Phonology” appears in the title of this paper because the analysis proposed here combines both traditional phonology and modern acoustic phonetics.

2.0 Research Design and Methodology

An acoustic phonetic study was designed to test the morphophonological claims that the past tense suffix represented orthographically as <-ed> has three allomorphs. An allomorph is defined simply as the different pronunciations of the same morpheme based on the phonological environments in which it occurs. Linguistic textbooks claim that the past tense suffix has three different pronunciations: [d], [t] and [əd]. Fromkin et al. (2011, pp. 270-271) contend that the underlying phoneme of the past tense is /d/. On the basis of this assumption, they propose the following rules to account for the allomorphs of the English past tense:

1. Insert a [ə] before the past-tense morpheme when a regular verb ends in a non-nasal alveolar stop, giving [əd].
2. Change the past-tense morpheme to a voiceless [t] when a voiceless sound precedes it.

Phonologists like to use abbreviatory conventions to summarize phonological rules. Accordingly, the two rules mentioned above are respectively restated formally as follows:

$$\emptyset \rightarrow [ə] / [+alveolar, +stop, -nasal] \text{ —}$$

$$/d/ \rightarrow [t] / [+cons, -voice] \text{ —}$$

Phonological rules tend to be normative; that is, they assume that all General American English (GAE) speakers would pronounce the past tense suffix exactly as prescribed by the rules. To put this claim to a test Doug, one of the co-authors, recorded himself and a friend named Jared pronouncing the words in Table 1:

Word	IPA	Expected Phonological Representation of Past Tense <ed>
<popped>	[papt]	[t], following voiceless bilabial stop /p/
<bobbed>	[babd]	[d], following voiced bilabial stop /b/
<toted>	[totəd]	[əd], following voiceless alveolar stop /t/
<duded>	[dudəd]	[əd], following voiced alveolar stop /d/
<cocked>	[kakt]	[t], following voiceless velar stop /k/
<gagged>	[gægd] or [gɛgd]	[d], following voiced velar stop /g/

Table 1: Data for Analysis

The recording took place in a quiet room, with an Olympus VN-8100PC recorder. Each token was repeated three times. All in all, the analysis is based on 36 samples: 3 x 6 x 2. The data was transcribed phonetically and then analyzed acoustically by using Praat, an online acoustic analysis software. Due to the limitation of space, only two spectrographic images of each word will be included in the paper. Some salient acoustic information found on each spectrogram will be commented on briefly.

3.0 The Acoustic Evidence for the Epenthetic Vowel

The first morphophonological rule proposed by Fromkin et al. states that an epenthetic vowel is to be inserted when the last consonant of the root of the word ends with a /t/ or a /d/. Therefore, when analyzing the words /tot/ (<tote>) and /dud/ (<dude>), one expects to see an inserted vowel between the last consonant of the word and the past tense suffix /d/. It is rather easy to verify this claim spectrographically because vowels show up as dark horizontal bands. These bands are called formants. In most acoustic phonetic studies, linguists pay attention only to the first two formants called F1 and F2. Let's examine Figures 1-4 to see if Doug and Jared inserted a vowel after the last consonant of /dud/ and /tot/. For ease of identification, if there is an epenthetic vowel, it is highlighted with a dark rectangle.

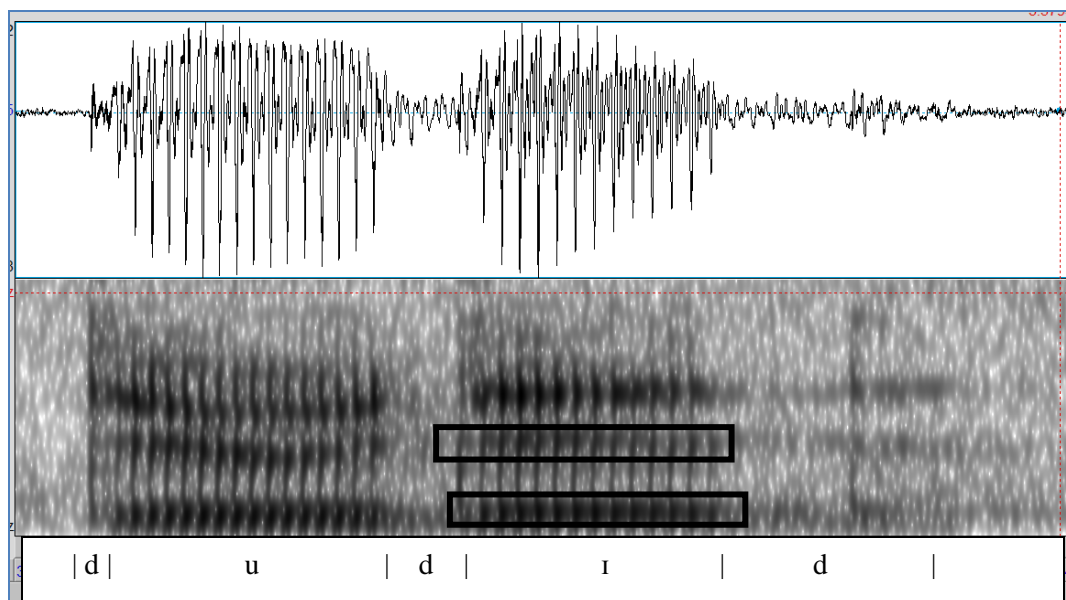


Figure 1: <duded> by Doug

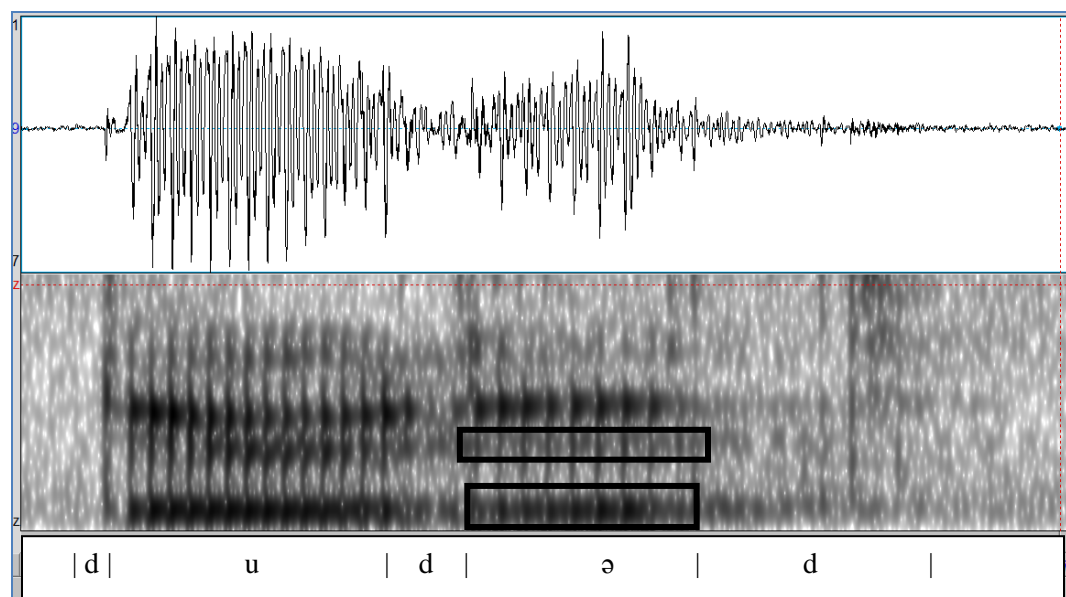


Figure 2: <duded> by Jared

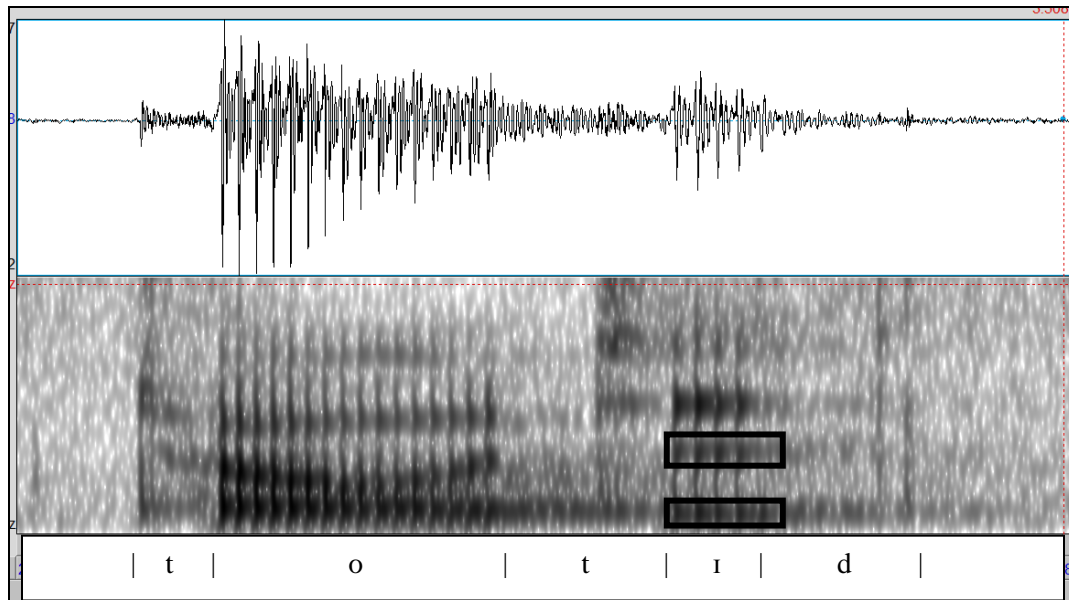


Figure 3: <toted> by Jared

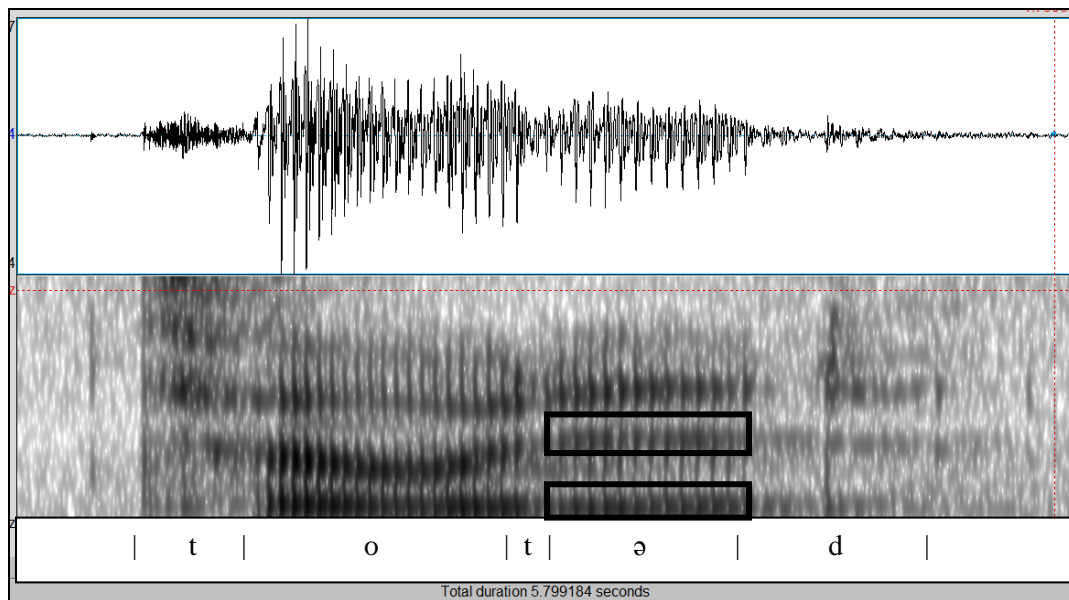


Figure 4: <toted> by Doug

One can see in Figures 1- 4 that a vowel is indeed inserted between /d/ and /t/, and the past tense suffix /d/. This confirms the first morphophonological rule stated by Fromkin et al.

Now, the rule makes a very specific claim about the nature of the vowel that is inserted. They claim that that vowel is a schwa [ə]. Is this claim correct? Do both Doug and Jared insert a schwa? Traditional phonological analyses are content with making this claim, but laboratory phonologists refuse to take such a statement for granted. For this reason, we need to investigate the matter further. Upon a closer examination of F1 and F2 formants, it appears that Doug and Jared insert two different vowels. The space between Doug's F1 and F2 formants is smaller than

that of Jared's. This indicates that Doug insert a [ə] whereas Jared adds a [ɪ]. Indeed, F1 and F2 frequencies in Table 2 bear this out.

Participants	Duded F1	Duded F2	Toted F1	Toted F2
Jared	377 Hz	1652 Hz	375 Hz	1522 Hz
Doug	411 Hz	1722 Hz	437 Hz	1647 Hz

Table 2: F1 and F2 Frequencies

In correlating F1 frequencies with vowel height, it is accepted that the higher the frequency, the lower the vowel. Since Doug's F1 frequencies are higher than Jared's, it means that he inserts the epenthetic vowel [ə] whereas Jared inserts [ɪ].

There are a couple of other acoustically noteworthy observations that can be made about how Jared and Doug differ in their pronunciations of /dud/ and /tot/. For instance, the spectrographic evidence in Figure 3 reveals that Jared pronounces the second /t/ of /tot/ with an aspirated stop burst. Doug, on the other hand, pronounces the second /t/ differently. There is no burst in his pronunciation. Instead, that /t/ is flapped ([ɾ]). This explains why there is no burst. Moreover, since [ɾ] is voiced, we see the voicing of the vowel [o] continue through to the vowel [ɪ]. Furthermore, the spectrographic image shows that Doug's flap is much shorter than Jared's aspirated [t^h]. According to Ogden (2009, p. 114), flaps are only 30-40 ms long.

4.0 The Acoustic Behavior of the Past Tense Suffix after Voiced Bilabial Stops

Voicing plays a crucial role in the second morphophonological rule formulated by Fromkin et al. The rule states that the past tense suffix behaves one way when it is added to words that end with voiceless consonants, and another way with those that end with voiced consonants. To verify the veracity of this claim, let's see how Doug and Jared pronounce the words /bab/ (<bob>). Since /b/ is a voiced consonant, the second rule predicts that the past tense suffix would be pronounced as [d]. Let's see how this prediction turns out.

In Jared's pronunciation of <bobbed> in Figure 5, we can see a clear burst release represented by the second [b]. We do not see a burst release for /d/, as one might expect even though it is an alveolar stop. Instead, we see a diffuse voice band at the bottom of the spectrogram. Since /d/ is a voiced consonant, we expect to see a darker voicing band. There is indeed a weak voicing bar which means that Jared slightly devoices the past tense suffix. Devoiced /d/s are transcribed phonetically as [d̥]s. The spectrogram reveals another characteristic of how Jared pronounces the past tense suffix. The area that appears in the square is indicative of a forceful release. Thomas (2011, p. 123, Figure 4.35) makes mention of such a release for the final /t/ in the word <fight>.

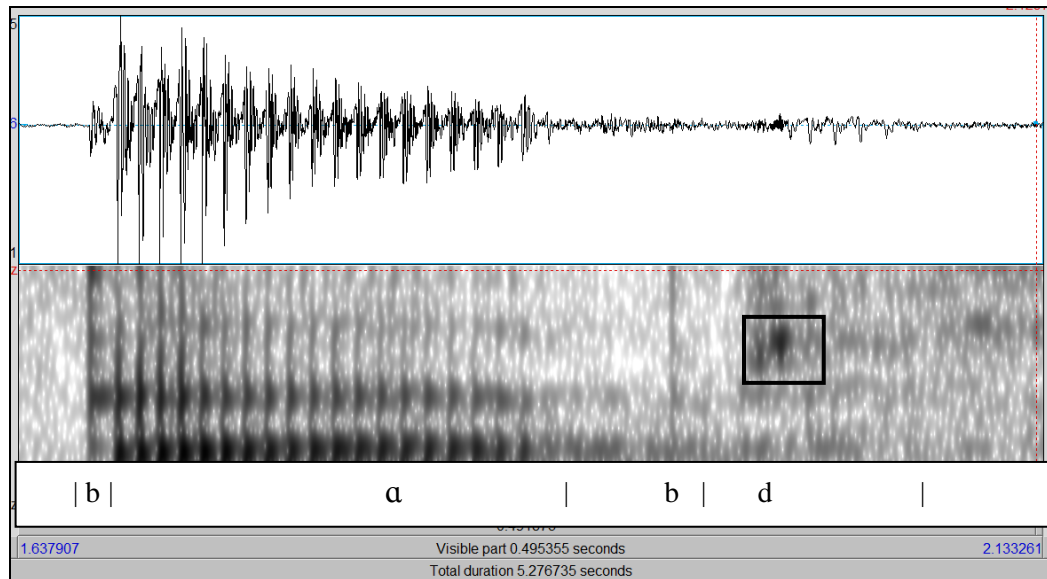


Figure 5: <bobbed> by Jared

Figure 6 shows that Doug's pronunciation of the past tense suffix is different from Jared's. The burst release of the second /b/ is clear in the spectrogram. There is also a clear burst release for /d/. The waveform and the spectrogram indicate that Doug also devoices [ɸ] because there is no voicing bar. Moreover, there is an unmistakable evidence that /d/ is aspirated, as shown by the aperiodic waves on the waveform.

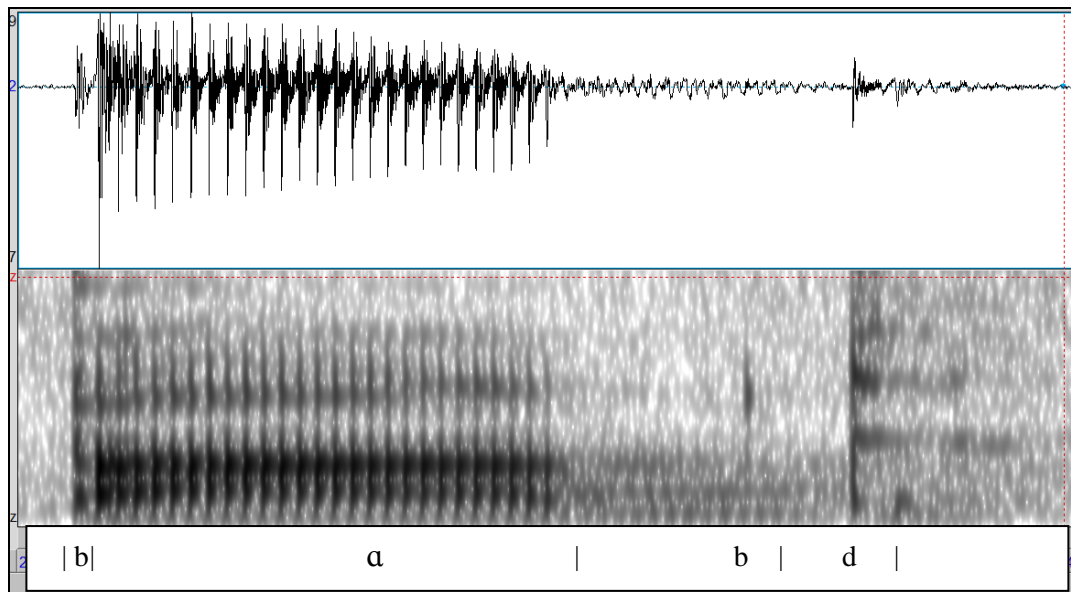


Figure 6: <bobbed> by Doug

The spectrographic and waveform evidence indicate that both Doug and Jared devoice the past tense suffix. This would not be entirely unusual because Yavas (2011, p. 10) includes English among the languages in which “the voiced consonants /b, d, g/ are subject to a certain amount of loss of voicing ‘partial devoicing’ during their production.” Ogden (2009, p. 100) has

found a similar pattern of devoicing among the British participants whose speech samples he has studied acoustically. He writes that “utterance-final [b d g] are often devoiced, and have no voicing or whispery voice, on release; this can be transcribed as [b̥ d̥ ɡ̥].” As for the differences between how Doug and Jared pronounce the suffix /d/, it can be seen that Jared forcefully releases /d/ whereas Doug aspirates it.

5.0 The Acoustic Behavior of the Past Tense Suffix after Voiceless Bilabial Stops

Let’s now turn our attention to the pronunciation of the past tense suffix when it is added to words whose final consonants are voiceless. The example chosen to illustrate this class of words is /pap/ (<pop>). According to the second morphophonological rule, the past tense suffix is to be pronounced as a [t] in such an environment. Since [t] is a voiceless stop, the spectrogram ought to show a stopgap followed by a burst release. Moreover, there should not be any voicing bar.

We can see in Jared’s pronunciation of /papt/ a diffuse burst release for [p]. It is followed by another diffuse burst release for [t]. There is also no voicing band after the weak burst releases of [p] and [t]. This confirms that Jared pronounces the coda cluster [pt] as voiceless. Moreover, the weak and diffuse burst releases of both [p] and [t] are an indication that both sounds are unreleased. In a narrow phonetic transcription, unreleasing is represented by the diacritic [̚]. Thus, Jared pronounces the coda cluster as [p̚t̚].

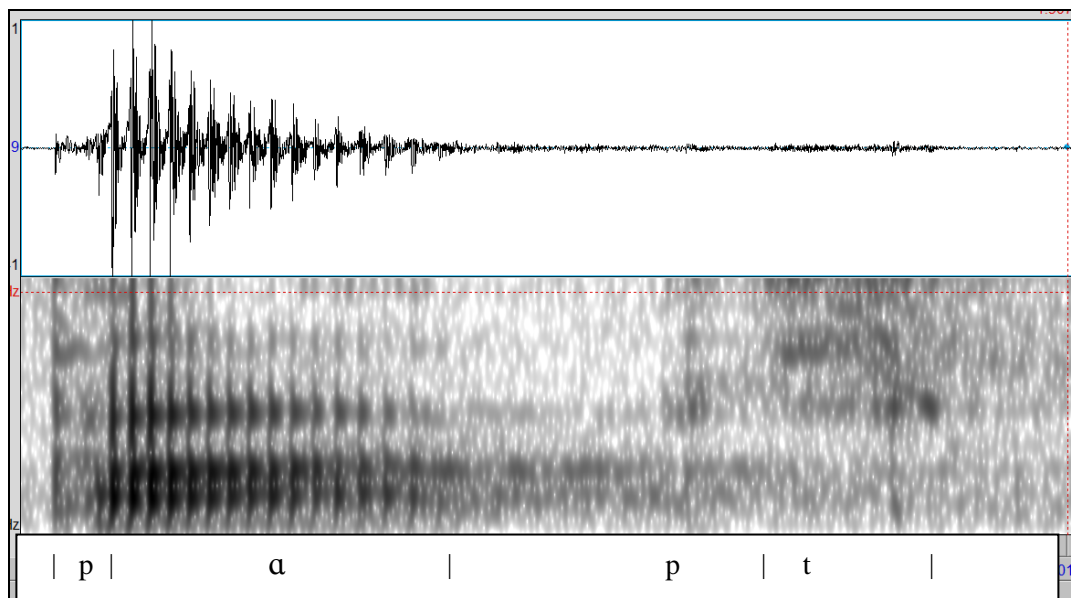


Figure 7: <popped> by Jared

The spectrogram in Figure 8 shows that Doug releases the second [p] fully. The burst release inside of the skinny rectangle shows it. As for the pronunciation of [t], we see that it is not only released but it is also forcefully aspirated. The force of this aspiration is indicated by the aperiodic waves in the upper frequencies inside of the circle.

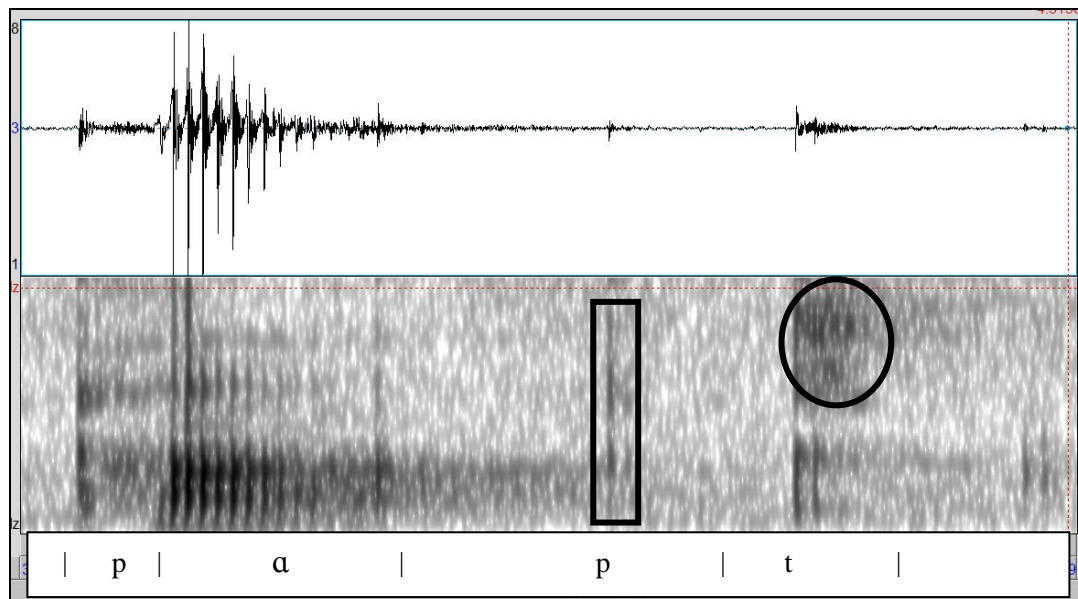


Figure 8: <popped> by Doug

Doug and Jared pronounce the past tense suffix fairly similarly when it is added to a voiceless consonant. The voiceless consonant and the suffix are both voiceless. However, the spectrographic images also reveal some differences between the two speakers. Jared unreleases the coda cluster [pt̚] whereas Doug pronounces /p/ fully and aspirates [t]. Thus, Doug's pronunciation can be transcribed narrowly as [pt^h]. As far as English morphophonological rules of the past tense suffix are concerned, Doug's pronunciation appears to be outside the norm for GAE. Phonologists claim that GAE speakers aspirate /t/ only if it precedes a stress vowel. However, the acoustic evidence shows that Doug aspirates /t/ even in the coda (see 7.0 for additional evidence).

6.0 The Acoustic Behavior of the Past Tense Suffix after Voiced Velar Stops

The analysis in this section parallels that of the previous section. The goal here is to further examine whether or not velars have any impact on how the past tense suffix is realized phonetically. Since [g] is a voiced velar, we expect to see the consonant cluster /gd/ in the coda when the past tense suffix is added. This means that we expect to see the following on the spectrograms: two burst releases that are characteristic of stops; one for /g/ and one for /d/. We also expect to see a voicing bar stretching from the vowel all the way to the end of the word. Do Doug and Jared's pronunciations conform to these expected patterns?

Jared's pronunciation of /gagd/ is as expected. We see two burst releases which are enclosed inside of skinny rectangles. We also see a faint voicing bar throughout the utterance. The second burst release is fainter than the first one. This is certainly due to the fact that [d] is unreleased.

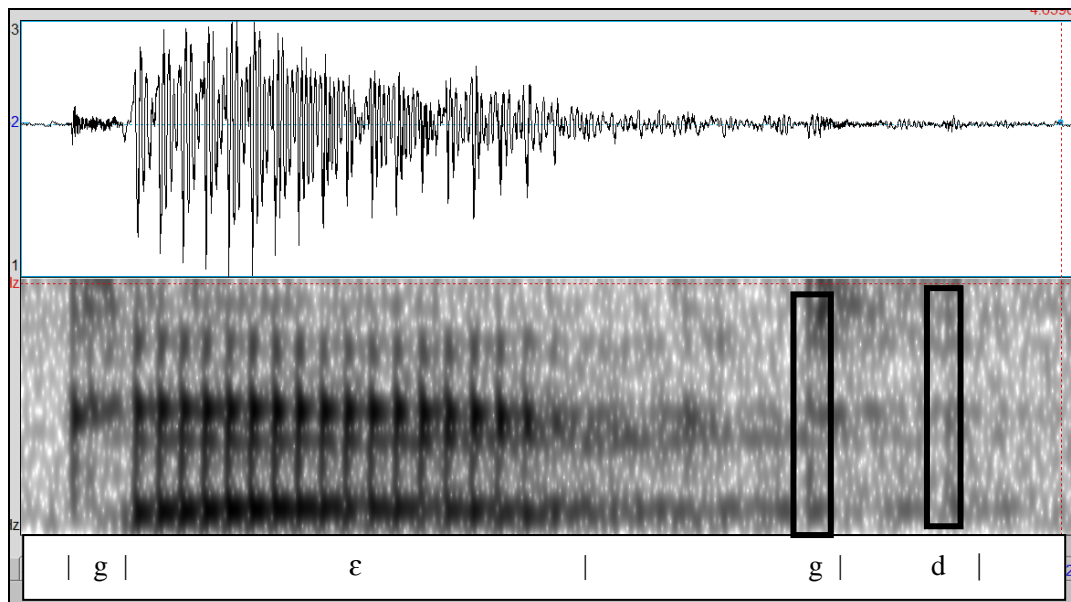


Figure 9: <gagged> by Jared

Figure 10 represents Doug's pronunciation. There is only one burst release that corresponds to /g/. This /g/ is devoiced, as evidence by the lack of voicing bar. Moreover, Doug seems to aspirate /g/. As for /d/, Doug hardly articulates it. It is so light that it barely registers on the spectrogram.

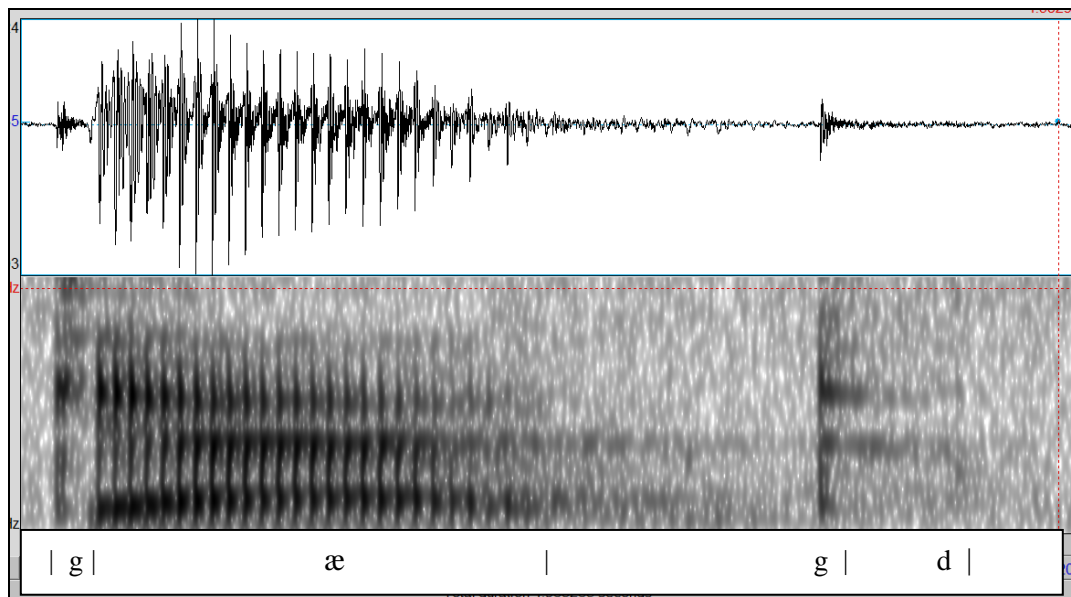


Figure 10: <gagged> by Doug

7.0 The Acoustic Behavior of the Past Tense Suffix after Voiceless Velar Stops

The final consonant of /kək/ (<cock>) is voiceless. According to the second morphophonological rule stated in 2.0, the past tense suffix should be pronounced as [t]. As a result, the expected pronunciation of <cocked> should be /kəkət/. Acoustically, there should be no voicing bar from [k] to [t]. However, since the cluster /kt/ is made up of two stops consonants, we expect to see two burst releases. Do Doug and Jared's pronunciations conform to these predictions? Let's find out by examining the spectrographic images in Figures 11 and 12.

The lack of voicing bar for the [kt] cluster is obvious in Jared's pronunciation. We also notice that there are two burst releases: one for [k] and another one for [t]. Both burst releases are aspirated, but [k] is more sharply aspirated than [t].

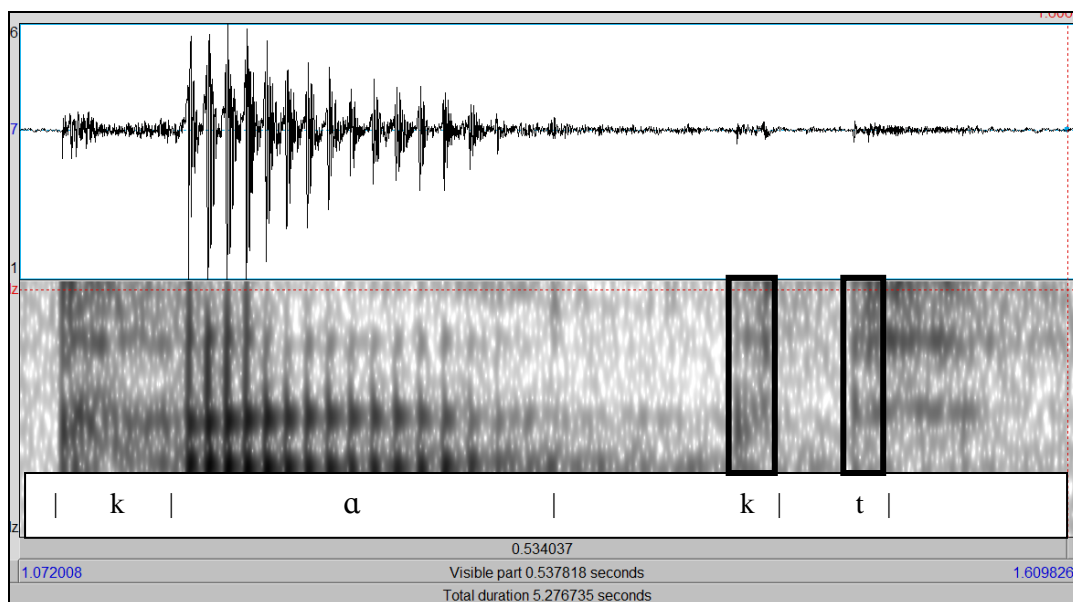


Figure 11: <cocked> by Jared

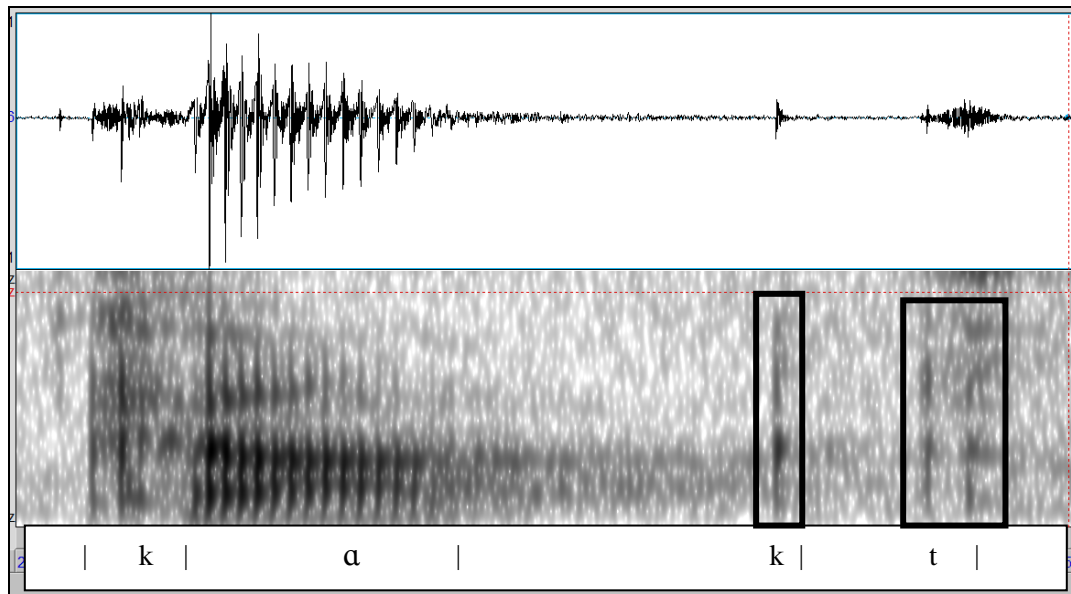


Figure 12: <cocked> by Doug

Doug's pronunciation is similar to Jared's in that the cluster [kt] is voiceless. However, acoustically there are differences. Doug has three burst releases instead of two. Moreover, in Doug's pronunciation, [k] is forcefully aspirated and released. The most obvious difference between Doug and Jared is the double burst releases for [t]. The spectrogram and the waveform indicate that there is some diffuse aspiration of [t]. This feature of Doug's pronunciation has been described as an "aspirated coda stop." Thomas (2011, p. 122) describes this phenomenon as follows:

Less common in Western languages is aspiration of coda stops. Docherty and Foulkes (1999) and Foulkes and Docherty (2006) describe the presence of 'pre-aspiration of /t/ (called 'extended frication' in an earlier paper in Tyneside English.)

The aspiration of [t] in the [kt] consonant cluster is similar to that of [t] in the [pt] cluster discussed in 5.0. On the basis of the data, it can be postulated that the rule of coda aspiration applies in Doug's idiolect but not in Jared's.

8.0 Summary

This exploratory analysis has yielded a number of important insights. Broadly speaking, both Doug and Jared pronounced the past tense according to commonly stated morphophonological rules, namely as [d], [əd], and [t]. However, the paper has also shown that there are significant acoustic phonetic differences between Doug and Jared. For instance, both insert different vowels after /t/ and /d/. Jared inserts a [ɪ] whereas Doug prefers a [ə]. Doug also shows a strong preference for devoicing and aspiration more forcefully than Jared. The pronunciation of the past tense suffix is also quite noticeable spectrographically after voiceless stops. Jared tends to unrelease the voiceless coda cluster [pt] as [p̥t̚], whereas Doug pronounces it as [p̥tʰ]. The tendency to aspirate the final [t] is also seen in [kt] clusters. Though Doug's pronunciation seems unusual for a mainstream account of General American English, researchers

have found evidence of it elsewhere.

The laboratory phonology account of Doug and Jared's pronunciations of the past tense suffix has also underscored the necessity of integrating phonetics and phonologically more fully. Pulleyblank is right in calling for such integration because traditional phonology alone cannot allow us to "figure out what's going on when something is hard to hear or see." Many of the fine acoustic details that cause Doug and Jared's speech to be different cannot be uncovered or accounted for if we rely solely on our ears. Maybe a large speech sample from the areas where Doug grew up will show that coda aspiration is not as uncommon in some dialects of English as has been previously thought.

ABOUT THE AUTHORS

Douglas LeBlanc spent the first 24 years of his life in different parts of the southeastern United States. Most of that time was spent in coastal Mississippi, where he was raised. He also he spent six years in northern Alabama, where he obtained a BA in English. He is currently living in Minnesota where he is studying for his MA in Applied Linguistics/TESL. **Jared**, the other research participant, grew up in Osakis, MN. After high school, he spent a few years in other parts of MN. He has been living in St Cloud, MN for the past few years.

Ettien Koffi is a Professor of Linguistics. He teaches the linguistic courses in the Applied Linguistics/TESL MA at Saint Cloud State University. His research interest is at the interface between acoustic phonetics and phonology.

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